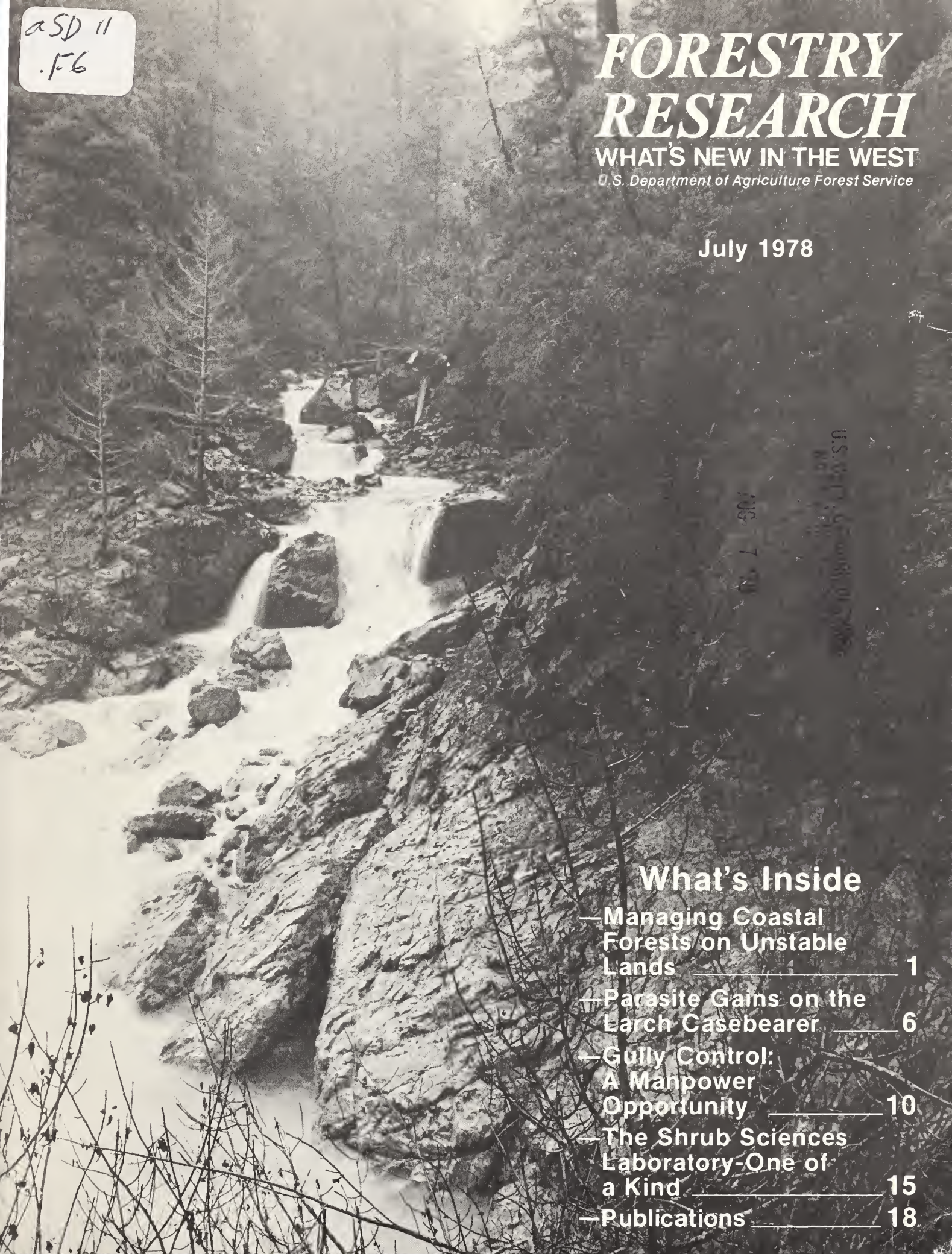

FORESTRY RESEARCH

WHAT'S NEW IN THE WEST

U.S. Department of Agriculture Forest Service

July 1978

What's Inside

a note to you

Forestry Research: What's New in the West, is a report on the work of the USDA Forest Service's four Forest and Range Experiment Stations in the West. These research centers, and the States included in their areas of study are: Rocky Mountain (North Dakota, South Dakota, Nebraska, Kansas, Colorado, Arizona, New Mexico, and part of Wyoming, Oklahoma, and Texas); Intermountain (Montana, Idaho, Utah, Nevada, and part of Wyoming); Pacific Northwest (Alaska, Oregon, and Washington); and Pacific Southwest (California, Hawaii, and the Pacific Basin).

on the cover

Streams in California's North Coast region supply more than one-third of the State's water supply. However, sedimentation resulting from natural landslides, logging, roadbuilding, and other activities, is threatening water quality in this area. Researchers at the Pacific Southwest Station's Redwood Sciences Laboratory at Arcata, California, are working on this and related problems. Read about it on the facing page.

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The North Coast region provides more than one-third of California's water.

Managing Forests on Unstable Lands

The redwood and Douglas-fir region of the Coast Range and Klamath Mountains in northwestern California covers an area extending from the California-Oregon border south to about 100 miles above San Francisco. The area provides more than 40 percent of California's timber products, 37 percent of its streamflow, and the most valuable habitat for salmon and steelhead trout in the State. But management of these important resources presents major problems.

One difficulty is that natural landslides commonly occur, eroding slopes and depositing enormous amounts of sediment in streams. The role that logging and its associated roadbuilding may play in contributing to this natural erosion and sedimentation needs to be better understood. Sedimentation is a threat to the high quality of water in the numerous small streams that interlace the region. These waterways provide some 7,000 miles of habitat for king and silver salmon and steelhead trout. Conducting timber harvesting operations in such a way that water quality will not be impaired is a major challenge to forest managers.

Obtaining regeneration is also a problem, particularly on hot, south-facing slopes, on landslide scars, road cuts and fills, or similar harsh sites. Sometimes cutover sites have to be replanted as many as three times in attempts to get an adequate stand established.

Researchers at the Pacific Southwest Station's Redwood Sciences Laboratory in Arcata, California, are concentrating on resource problems of this complex ecosystem. The staff works in cooperation with Humboldt State University (where the Laboratory is located), and with forest managers throughout northwestern California. Results of the research are applicable not only in this area, but also in portions of Oregon, Washington, Alaska, Idaho, and British Columbia, where geological, biological, and climatic conditions are similar to those of the North Coast.

Much of the research on the effects of road construction and logging on water quality and flood peaks has been done in the Caspar Creek drainage on Jackson State Forest, a site that is representative of other watersheds of second-growth redwood and Douglas-fir in northwestern California. Streamflow and sediment loads of both the North Fork and South Fork of the drainage have been monitored for the past 14 years. The North Fork has not been logged during that period; in the South Fork, 62 percent of the timber was harvested after 4 miles of logging roads were built.

Preliminary results show that the road-building did not affect flood peaks, but it did increase sedimentation. The records showed that over the 4-year period between the beginning of road construction and the beginning of timber cutting, the South Fork watershed produced 1,340 cubic yards more sediment per square mile of drainage area than predicted. Logging increased the suspended sediment loads four times more than road construction—about 6,150 cubic yards per mile of drainage.

These sedimentation levels are not excessive, however. According to Raymond M. Rice, principal hydrologist at the Laboratory, "The overall effect on site quality, as measured by soil loss, was not of the magnitude to warrant the concern of forest managers. Although 14 percent of the eroded material left the watershed, prorated over an entire rotation, this is about one-seventh of one percent of the total soil mass lost each year. A timber harvest such as the South Fork operation would not cause unacceptable damage."

At the request of the State Board of Forestry, researchers are examining 102 sites

Research at the Redwood Sciences Laboratory, Arcata, is designed to improve management of the redwood and Douglas-fir forests in northwestern California. (Karl Riek photo courtesy California Redwood Association.)

throughout the coast redwood region that have recently been logged, to determine if there is any relationship between the type of logging operation (tractor or cable), site characteristics (such as slope, soil, and rainfall), and the erosion associated with a timber harvest. Sites on both National Forests and privately owned land are being studied. Preliminary results from the Forest Service sites show that in the tractor-yarded areas, more soil displacement occurred during the actual yarding operations than during subsequent storms. On the Forest Service plots that were cable-yarded, the results were the opposite: less than half of the logging-related soil displacement occurred during yarding.

Robert B. Thomas, mathematical statistician at the Laboratory, is trying to improve the techniques that are used to sample and monitor sedimentation. The data gathered under these improved techniques can be used in statistical or mathematical models of the processes involved in sedimentation. When completed, these models can be used to predict the results of proposed management activities.

In the Douglas-fir forests that lie east of the redwood belt, researchers are studying the problems associated with logging on steep, granitic batholiths. Here, landslides—especially debris avalanches—frequently occur as a result of logging. Geologist Philip B. Durgin has found that landslide susceptibility changes as the parent material weathers. "Landslides are most frequent when granitic rock is at an intermediate stage of weathering," Durgin explains. "In the early stages, there is not enough mobile material for there to be much of a landslide problem. In the later stages, the aggregation of clay and soil produces cohesion that promotes slope stability." Durgin regards a site's weathering stage as an important clue to its engineering properties. "An engineering geologist who is able to identify the weathering stage of a site will be better able to predict how a proposed management plan might affect the stability of slopes in the area," he says.

Raymond Rice and Norman H. Pillsbury (California Polytechnic State University, San Luis Obispo) have developed an equation foresters can use to predict landslide risk on granitic sites. In their research, they used photos of a portion of the Klamath National Forest, taken before patchcutting, after cutting, and after severe storms triggered landslides throughout the area. They compared characteristics of cut sites that had failed with those that had not, and found that steepness of slope and density of crown cover and understory cover were key factors. Tests of their equation showed that it correctly predicted 91 percent of the failures and 75 percent of the instances in which sites remained intact. In areas similar to that used in the study, the equation can be used in evaluating the slide hazard of proposed timber harvests.

Hydrologist Robert R. Ziemer is leading a study to determine how logging affects the role that roots play in maintaining slope stability. Roots reinforce unstable slopes by tieing the soil mantle to the parent material and by providing lateral support to the soil mass. "The increase in landslides that often occurs following logging may be related to the death and gradual decay of root systems in the harvested areas," Ziemer says. As part of this research, roots excavated from sites in California, Oregon, and Alaska that were logged 2 to 70 years previously have been weighed, measured, grouped into size classes, and tested for shear strength (their ability to resist the shear stress that is continually acting upon slopes). At some sites, a portable shear apparatus, developed by Ziemer, was used to measure shear strength of the soil-root matrix at the excavation sites. Preliminary results suggest that 6 years after logging, roots have deteriorated to the extent that they have only 10 percent of the soil-holding capacity they had before logging.

Regeneration

The root strength studies point up the importance of establishing a new stand as soon as possible after harvesting. Laboratory scientists are looking for ways to improve natural and artificial regeneration of redwood and Douglas-fir on a variety of sites. A

Although coast redwood is internationally famous, more needs to be known about how to grow, harvest, and regenerate this species. Research foresters at the PSW Station are developing guidelines for redwood management.

study conducted by Research Forester James L. Lindquist will show how growth of redwood sprouts is influenced by different levels of overstory stocking or by the diameter of the parent stump. "Redwood is unique among western commercial conifers in its ability to sprout many vigorous new stems from the stump shortly after harvesting," Lindquist says. "Sprouts are just as important as seedlings, if not more so, in redwood reproduction: trees of sprout origin may comprise as much as 55 percent of a young stand after old-growth is harvested, and stands that develop after the harvesting of young-growth could have an even higher percentage of sprout-originated crop trees." For the study, young-growth stands have been thinned to either 25, 50, or 75 percent of the original basal area of the plot. Stumps were classified according to their size, and will be checked periodically after thinning to determine the number of sprouts produced per stump, and the mean height and diameter growth of the tallest sprouts.

At other sites, Research Forester Rudolph O. Strothmann is testing the response of previously unthinned stands of commercial-sized young-growth redwood and Douglas-fir to repeated thinnings. Several well-stocked, 40-year-old stands were thinned to 25, 50, and 75 percent of the basal area of the control plots. The stands will be thinned again at age 45, 50, and 60, and will be harvested at age 70. At each thinning interval, the basal area and cubic and board foot volume will be recorded, to see how much these measurements have increased since the previous thinning. The study is needed because few formal thinning trials have been conducted for young-growth redwood, despite the fact that these stands make up the largest acreage of commercial redwood.

In another study, Strothmann will be comparing growth of containerized redwood seedlings with that of bare-root stock. "With the increasing interest in planting coast redwood, there is a definite need for field tests to learn about the relative merits of the two types of planting stock," he explains. The test, which he believes is the first of its kind for coast redwood, will involve measuring the survival and growth, over a 5-year-period, of about 200 seedlings that have been planted on a clearcut site.

In other research, scientists are developing tables for estimating future growth and yield of young, even-aged Douglas-fir stands of various densities. They will later develop tables for forests that have undergone routine thinning or cutting operations.

Fish habitat

Fish habitat research at Arcata is focused on the effects logging, roadbuilding, and other forest management activities have on physical parameters of fish habitat, such as the configuration of stream channels, the movement of suspended sediment, and the location and quality of areas for feeding,

hiding, resting, and spawning. In one investigation, streamflow and the rates at which heavy (bedload) sediment is transported are being compared in a logged and an unlogged drainage. Another investigation will determine the current and projected rates at which North Coastal streams are recovering from the depositing of huge loads of sediment that occurred during the 1964 and 1975 floods.

A separate study will investigate sedimentation of riffles and pools. The fastwater riffles provide the best feeding and cover areas for young fish (fry), while the deeper, current-free pools are the best rest areas for migrating adults. The ideal habitat, which has both riffles and pools, can be degraded by sedimentation.

Scientists are studying the long-range effects that erosion has on the quality of water in small forest streams.

The Laboratory is sponsoring several cooperative studies of forest management effects on fish habitat. Carlton S. Yee (Humboldt State University) is studying movement of gravel in the beds salmon use for spawning. Some movement is beneficial, because it removes fine sediment. The sediment could otherwise clog gravel interstices, slow down oxygen delivery to the eggs in the gravel nests, or form a physical barrier to the recently hatched fish that are trying to emerge from the gravel. But, too much movement can crush the eggs or fry. Yee's study will show when and how much gravel movement occurs, and what variations in streamflow trigger the movements.

A cooperative study with William V. Allen (Humboldt State University), concerns chemoreception—the process by which salmon detect odor signatures of trace amounts of organic compounds. The fish use these signatures during migration to find their way back to their home stream. Allen's intent is to find out if decomposition of needles, bark, and other debris that may fall into streams during logging, interferes with chemoreception. The study involves periodic sampling of streamwater in logged and unlogged drainages to determine variations in the composition and concentration of the compounds that are important in chemoreception.

In all these North Coast studies, researchers are dealing with a unique and highly productive ecosystem. The region's coast redwoods are the world's fastest-growing conifers. Its streams are major sources of water and are valuable habitat for fish. Its problems—fragile soils, unstable slopes, and rivers with some of the highest sedimentation rates of any in North America—are as impressive as its assets. Scientists at the Redwood Sciences Laboratory are helping land managers to meet this region's challenges and to fulfill its potentials.

-by Marcia Wood,
Pacific Southwest Station

A list of recent publications about the North Coast studies is available from the PSW Station. For copies, write to: Publications Section, PSW Station, P.O. Box 245, Berkeley, CA 94701, and ask for the "Forestry Research" list of Redwood Sciences Laboratory publications. Researchers named in this story can be contacted by phone at (707) 822-3691 (FTS: 461-5318) or by writing to them at the Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521.

Parasite Gains on the Larch Casebearer

Adult female of Chrysocharis laricinellae lays an egg in a casebearer larva, which is inside its case—a portion of a larch needle.

The larch casebearer, an upstart immigrant from Europe that has been chewing its way through the needles of western larch for the past 20 years, may be on its way out as a pest of western forests. The casebearer is being killed off by a tiny insect parasite called *Chrysocharis laricinellae*.

The parasite had been imported from Europe and raised in the research laboratories of Entomologist Roger Ryan of the Pacific Northwest Forest and Range Experiment Station in Corvallis, Oregon, for the special purpose of being introduced in western forests. Ryan predicts the doom of the casebearer on the basis of a 1977 survey of infested larch in four western states, including locations where the parasite was released a few years ago. "There is no guarantee of success at this point," Ryan says, "but the outlook is very promising. I feel confident that the parasites will do the job."

The survey covered 160 sites. Most of the samples were taken by entomologists with the Forest Service's Northern Region. They found that the parasite had become established at several locations and had killed up to 68 percent of the casebearers. Highest parasitization levels were found at the oldest and largest establishment sites. "This is significant," says Ryan, "since it indicates that the parasite is building up and is spreading." The parasite was first released in large numbers in 1973.

The casebearer, which was accidentally imported to North America from Europe in 1886, has become the most important pest of western larch. It has reduced growth up to 50 percent on larch trees in Idaho, Montana, Washington, and Oregon. A Forest Service estimate places the loss of stumpage value at $3 million per year over the total infestation.

"Forest managers who have wondered whether to discriminate against western larch in management programs because of its uncertain future can rest easy," says Ryan. "They need not discriminate. I feel confident that within a few years the casebearer, will be reduced to non-pest status."

The larch casebearer, *Coleophora laricella*, was discovered near St. Marie's, Idaho in 1957 and has since spread over most of the range of western larch. The larvae feed on larch needles, reducing tree growth and weakening the trees. The insect spends part of its larval stage inside a portion of a single needle, the "case" from which it gets its name. When fully grown, the larva is about 5-7 mm. (3/16 inch) long. Because larch grows new needles each year, it can withstand defoliation for several years but may eventually die if severe defoliation persists.

Efforts to curb the infestation began in 1960, when the Intermountain Station of the Forest Service selected as a promising control agent one of the casebearer's natural European parasites *(Agathis pumila)* and introduced it at five sites in Idaho. Additional releases were made subsequently by entomologists with the Northern and Pacific Northwest Regions on some 300 sites in Idaho, Montana, Washington, and Oregon. Surveys in the late 1960's indicated that while this particular parasite was doing well in some places and had reduced the casebearer population somewhat, it was doing poorly at other sites and could not be depended on to control the casebearer without assistance.

In 1972, Ryan, who has had extensive experience with parasitic insects, became a cooperator in efforts to control the infestation. He obtained a few specimens of another casebearer parasite *(Chrysocharis laricinellae)* from Wisconsin, where it had been established from European ancestors released in the 1930's. *C. laricinellae*, like *A. pumila*, is one of several larval parasites of the casebearer. The adult stage of *C. laricinellae* is a tiny, fly-like wasp. The fully grown larvae are only 1 to 3 mm. long.

Laboratory rearing

Ryan decided to tackle the problem of rearing the casebearer and its parasites in the laboratory the year around, even though previous attempts by others to do this had not been successful. Laboratory rearing offers three advantages. Parasites can be released in forests when the casebearers are in the proper stage to be parasitized, the number of parasites available for release can be increased, and the little-known biology of the parasitic insects can be studied.

Raising parasites requires a constant supply of host insects. Since a host requires a continuous supply of food—in this case larch needles—Ryan's first task was to get the deciduous larch to produce foliage on demand. After experimenting with various combinations of temperature and light, he was able to fool potted larch trees into producing foliage at any season of the year—even during the winter. Using similar day-length simulation, he also persuaded the casebearer to produce several generations a year instead of one. Once these rearing methods were established, Ryan could perpetuate the species and build up the supply of parasites for releases in spring and summer.

Adult parasitic wasps, which developed inside casebearer larvae on larch trees, are collected. Plastic bags form cages around the trees.

Ryan opens a package containing parasites shipped from Europe through strict quarantine.

Since 1972, Ryan has raised and released more than 17,000 *C. laricinellae* and lesser numbers of five other species of parasites. Ryan felt that since there was no way of knowing in advance which species would adapt to the environment of western forests, releasing several species would increase the chances of control of the casebearer infestation.

Although Ryan travels to the field to make some of the releases, most are made by cooperators at the Intermountain Station, the Northern and Pacific Northwest Regions of the Forest Service, the States of Oregon and Washington, and the Boise Cascade Corporation.

To monitor the progress of introduced parasites, Ryan and the cooperators collect sample larch branches at sites where the parasites were released and at non-release sites to compare the effects of the parasites. Collections are made in June, when the casebearer is in its pupal stage. In the laboratory, larch needles containing pupae are picked off each branch and placed in covered dishes. In a few days the adults emerge and die. Since the parasite larva pupates in the case where it has killed and eaten the casebearer larva, some of the emerging insects are adult parasites. The others are casebearers which were not parasitized. The various species of parasite are identified under a microscope. It is a simple matter to count each species and compute percentages of parasitization by species.

Ryan examines live parasites removed from larch foliage with a mouth aspirator. Parasites can be examined under a microscope while in the tube.

Bob Oakes, a technician at the Intermountain Station in Moscow, Idaho, releases casebearer parasites in the field.

The major source of casebearer parasites has been the European Station of the Commonwealth Institute of Biological Control. Insects collected in Austria, Italy, England, Switzerland, and Germany are sent through this agency. Parasites have also been obtained from cooperators in Sweden, Poland, and Japan. Only a relatively few individuals are sent at a time, and these serve as rearing stock. The insects are held in quarantine at the Beneficial Insects Research Laboratory at Newark, Delaware, before being released to Ryan to make sure no undesirable foreign material enters with the beneficial insects.

Since it takes several years for imported insects to become established and multiply, Ryan plans to continue monitoring parasite effects on his research plots for several more years. The most promising species of parasite in Europe has also proven to be the most difficult one to culture in the laboratory.

Introducing parasites to control the casebearer is an example of biological control, an approach to pest management which many entomologists feel is ideal. The initial cost is small. If it is successful, there are no recurring costs, the results are permanent, and the whole problem of pesticides is eliminated. There are no adverse effects on the ecosystem or other organisms because parasites affect only their hosts. Since parasites are completely dependent on the host insect, their numbers will decline as numbers of the host are reduced until the two are balanced at low levels.

This is the situation in Europe and Japan, where the casebearer is native. It is also the case in the eastern United States and Canada, where *A. pumila* and *C. laricinellae* were introduced in the 1930's to control an outbreak that began in the early 1900's. Methods used in the East were the basis for the control effort in the West.

According to Ryan, 157 species of insects have been controlled by introducing natural enemies, and the number is growing each year. Many of these successes have been repeated in several different countries for a total of about 327 successful cases of biological control. Ryan says, "Many entomologists feel that importation of new natural enemies from abroad should be the first step in developing an ecological pest management program and that it should receive greater emphasis and financial support."

-by Dorothy Bergstrom, Pacific Northwest Station

Gully Control - A Manpower Opportunity

This 1933 photo shows members of the Civilian Conservation Corps constructing log-loose rock check dams on a watershed in Colorado. Note the use of untreated logs. This practice is not recommended today due to relatively fast rotting.

Gullies are a far-too-common sight in the western United States. They hinder the percolation and storage of water in the soil, while increasing runoff and peak stream flows during storms. Gully erosion results in the loss of productive rangeland and wildlife habitat, lowered water tables, increased sediment-load in streams, decreased water quality, and disruption of land management functions.

During the 1930's, the Civilian Conservation Corps and the Public Works Administration undertook numerous gully control projects. From a social standpoint, they were successful because they put people to work. From a technical standpoint, many of the projects were not so successful. For example, logs were used extensively to construct check dams. It was not long, however, before rot set in and the structures failed, sometimes creating more serious erosion problems than existed originally. Other types of structures proved more successful and accomplished at least a measure of their intended purpose.

Today, a unique opportunity exists to advance gully control beyond the achievements of the Public Works Administration and Civilian Conservation Corps Programs. First, we can learn from and avoid the failures of those early efforts. Second, the Young Adult Conservation Corps, Youth Conservation Corps, Volunteer Programs, Neighborhood Youth Corps, Job Corps, and similar programs can provide manpower to do the work, freeing agency appropriations to develop plans and purchase materials. And third, gully control technology has come a long way since the 1930's.

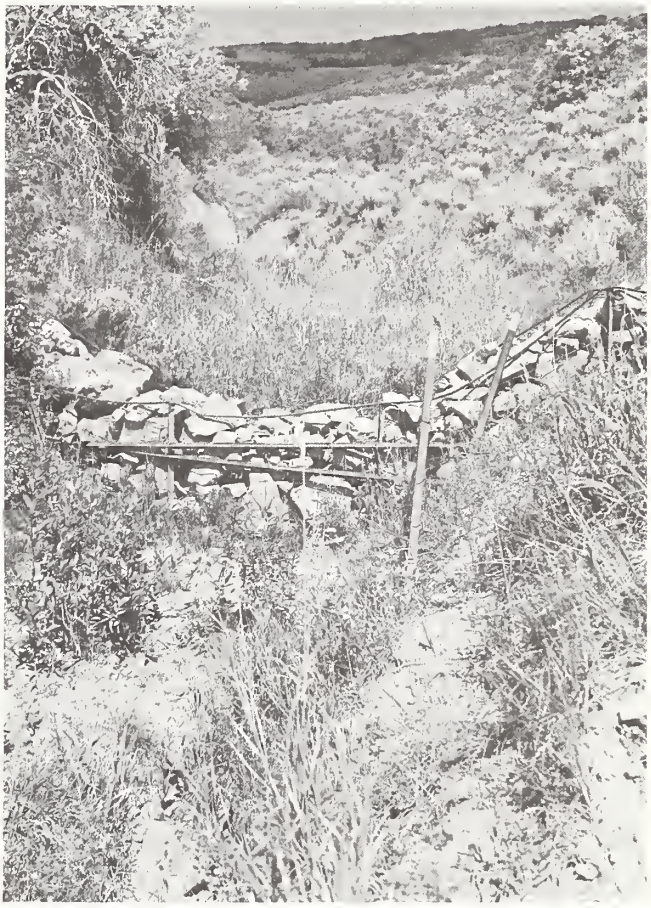
With the growing national need for water quality and quantity, gully control becomes an essential element of many watershed management programs.

Planning and cost cutting

Burchard H. Heede, research hydraulic engineer with the Rocky Mountain Station's Forestry Sciences Laboratory in Tempe, Arizona, says, "the cost of gully control can be decreased by increasing the effectiveness of treatments. Past research on engineered control emphasized the design and construction of individual structures. Yet, the individual structure represents only one component of a treatment system. The quality of the treatment *as a whole* determines success or failure. One gully on a watershed cannot be singled out for treatment and the remainder of the gully network neglected. With improved planning methods, and labor funded through today's manpower programs, the opportunity exists to initiate effective gully control with modest funds."

Heede points out that before designing a control and restoration system, the initial cause of erosion, such as grazing, off-road vehicle use, logging activities, etc., must be overcome. Then the entire gully network must be analyzed. Each gully type has its own characteristics that indicate critical locations within the system and relationships among the gullies.

"Types of gullies and stages of gully development are important factors in the design of control measures because they indicate future changes in channel morphology (form and structure) and expected erosion rates," he explains.



A properly constructed and maintained check dam has decreased erosion and allowed vegetation to take hold.

According to Heede, there are three types of gully systems: one consisting of continuous gullies (starting high on a mountainside with many small rills merging and connecting with adjacent gullies downstream); discontinous gullies (beginning with an abrupt headcut at any location); and systems containing both continuous and discontinuous gullies.

The analysis of a gully system must also include stream ordering - looking at how a particular gully influences and connects with other gullies within the system; and gully ranking, where three or more stages are classified: young, mature, and old. Each stage

Top photo shows an untreated gully on the Alkali Creek watershed. Three years later, bottom photo, following conversion to a vegetation-lined waterway.

signifies relatively large, medium, and small volumes of expected erosion, respectively.

Gully system analysis provides a necessary objective measure to determine treatment priorities where control measures must be focused.

Treatments

Heede explains that, "treating gullies with expected large erosion rates will yield larger benefits than those with insignificant rates. Highest benefits can be expected from the control of discontinuous gullies that have not yet joined a network. Gullies with sloped, vegetated banks and bottoms on bedrock are usually classed as low priority. Not all treatments need be done at once, but it is important that treatment proceeds from the highest to the lower-order gullies, unless local bedrock controls exist. These should be used as takeoff points for treatment.

A recent publication titled "Gully Development and Control," Research paper RM-169-FR15, By Dr. Heede, covers many key factors in types, designs and construction procedures for gully control structures. It can be ordered from the Rocky Mountain Station.

The most commonly used gully control structure is the check dam — the most popular being the porous type. A porous check dam is usually built of loose rock, reinforced by wire mesh, steel posts, or other materials.

Non-porous types may be a single concrete slab or steel or fiberglass sheet. The porous dam has proven the better of the two because it releases part of the flow through the structure, thereby decreasing the flow over the dam and the dynamic and hydrostatic forces acting against the dam. The result is less erosion and a longer dam life.

Another effective, but less popular, method for gully control is called the "vegetation-lined waterway." Here, the land is reshaped, lengthening and widening the new waterway, as compared to the original gully, to decrease flow velocities and allow vegetation to become established. Small, discontinuous gullies often are suitable for conversion to vegetation-lined waterways. Field tests showed that the installation of waterways costs 8 percent less per meter of gully length than check dam treatments. However, waterways are not as popular as check dams because they require exact construction, and frequent inspections and maintenance during the first treatment years. On a gully control system established in Colorado, 19 percent of the original cost was expended on initial maintenance of vegetation-lined waterways, while only 4 percent was required for maintenance of check dams.

A third control measure is the earth dam which spreads water flowing in the gully onto

the surrounding land. Its use, however, is restricted because the land outside the gully must be well stabilized by an effective vegetation cover or by some other means.

Revegetation

Following the installation of check dams or other structures, and the subsequent stoppage or reduction of erosion (if all goes well), the next step is to see that the treated area is revegetated either naturally or by seeding or planting. Herbaceous species are preferred in the West because they control soil erosion faster and more efficiently than trees or brush.

"If feasible," says Heede, "container planting should be considered for severely depleted sites. Well established seedlings have a head start over other vegetation methods, thus speeding erosion control. Livestock grazing, recreation activities, vehicle travel, and other uses may need to be curtailed or excluded until plant cover is sufficient to achieve erosion control objectives." Additional design criteria can be found in "Designing Gully Control Systems for Eroding Watersheds," by Dr. Heede, from Vol. 2, No. 4 of "Environmental Management."

Upstream view of a properly installed double-fence, loose rock check dam.

Constructing a vegetation-lined waterway.

An example

Let's take a look at a watershed restoration project on the White River National Forest in northwestern Colorado that illustrates several of the principles discussed so far.

Depletion of the Alkali Creek watershed through gully formation was the combined effect of drought and overgrazing as well as misuse of nearby agricultural lands. In 1951, the Secretary of Agriculture ordered a 15 percent livestock reduction and a 5-year range improvement program. Help from scientists at the Rocky Mountain Station was enlisted to test gully control and watershed rehabilitation measures, and to develop new methods for restoration.

It was decided to treat nine gullies, representing 40 percent of the 5.45 miles of gullies on the watershed, by check dams. A total of 132 were designed of loose rock or a combination of loose rock with wire mesh and steel fenceposts. Four gullies, with a total length of 1900 feet, were converted to vegetation-lined waterways.

Plant selection and fertilization were important aspects of the design. Vegetation rehabilitation for the disturbed areas was

carried out in two phases. First, pioneer species were planted consisting of a mixture of an annual rye grass and yellow sweetclover. Second, a perrenial grass cover was established — mainly smooth brome and intermediate wheatgrass. Heavy and repeated fertilization made quick vegetation possible.

When structure installation and other treatment activities were completed, the access road, temporary roads, and all other disturbed areas were repeatedly seeded to grass until a satisfactory vegetative cover was achieved.

What are the results of this project 12 years later? Check dams accumulated a total of 69,000 cubic feet of sediment, resulting in a substantial decrease in overall gully depth. This decrease, coupled with bank stabilization, led to gentler gully side slopes, and hastened the establishment of vegetation. The ephemeral flow reverted to perrenial flow after 7 years of treatment.

The gullies that were converted to vegetation-lined waterways changed the regimen of runoff, lowering erosion rates to less than 1/5 of those on gullies not treated; and the grazing resource was significantly improved.

An example of a prefabricated, prestressed concrete check dam.

Even gullies that were not treated benefited; annual soil losses from the watershed during the last 10 treatment years were 78 percent less than during the first 2 years. These gullies benefited from both vegetative management and check dam treatments in other gullies.

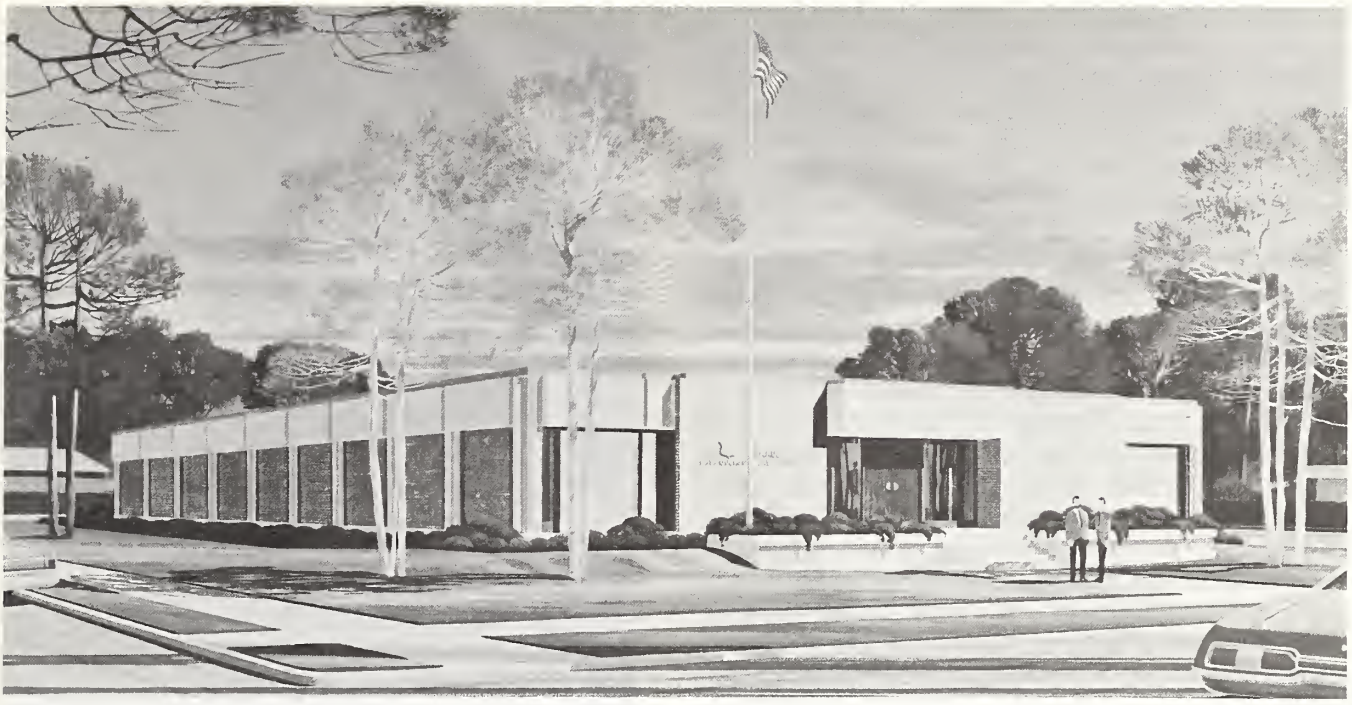
Cattle removal and grazing reduction resulted in a bare soil decrease of 12.6 percent outside the gullies.

Although erosion is still active locally, stabilization processes continue and the overall Alkali Creek Project goals have been achieved. Details on the Alkali Creek Study can be found in "Case Study of a Watershed Rehabilitation Project: Alkali Creek, Colorado," Research Paper RM-189-FR15, by Burchard Heede. It is available from the Rocky Mountain Station.

Growing concern over our nation's water supply and its importance for agriculture, domestic use, recreational activities, and as a means for transportation is increasing the need for sound watershed management. Effective gully control can play an important role in meeting these needs.

If you would like further information on research discussed in this article, call or write Burchard H. Heede at the Rocky Mountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Arizona State University, Tempe, Arizona, 85281. Phone, commercial and FTS, (602) 261-4365.

-by Rick Fletcher
Rocky Mountain Station



SHRUB SCIENCES LABORATORY — producing information to improve wildland shrubs and make shrublands more productive to meet society's needs.

The Shrub Sciences Laboratory— One of a Kind

Since the arrival of the white man, shrub ecosystems have been exploited and despoiled by his livestock and land management practices. The distribution and composition of many plant and animal communities have been substantially altered. The value of shrubs has long been underestimated. They provide habitat for wildlife, browse for livestock and big game, beauty to landscapes, and stability to disturbed soils or eroding sites. Shrubs are the major sustenance of most big game in winter. Despite these values, much shrub research in past decades has been directed toward eradication and control of shrubs.

When the Intermountain Station's Shrub Sciences Laboratory, Provo, Utah, opened in 1975, it became the world's first facility devoted principally to wildland shrub research. Maintained in cooperation with

Brigham Young University, the Laboratory is located near the center of the 400 million acres of shrubland in the Western United States. The Rocky Mountains, Great Basin, and Colorado River Plateau are all nearby.

Research at the Shrub Sciences Laboratory is primarily conducted by two research work units and by two members of the Station's Watershed Protection and Rehabilitation unit headquartered in Logan, Utah. Several biologists from Utah State's Division of Wildlife Resources, and visiting scientists from various institutions, cooperate in many of the studies. The research program also is augmented by close coordination with other institutions and agencies.

The Shrub Improvement and Revegetation unit is a major multifunctional team—its personnel include specialists in genetics, botany, physiology, ecology, entomology, and range science. This unit's research assignment is to select and breed superior shrubs and trees, and evaluate them in uniform gardens and outplantings; and to develop new seed technology, nursery stock production methods, and planting procedures. They are also seeking to determine the ecological effects of diseases and insects on shrub growth and reproduction, and methods of pest control. Another phase is development of shrubs and trees, including methods for their care, for use in recreational areas.

Establishing shrubs so they can perform their many useful functions sometimes is difficult. A continuing effort is underway to provide information on how to better establish shrubs on a wide range of sites.

A. Perry Plummer, foreground, discusses material from a western shrub with Dr. Howard Stutz, left, and Dr. Kimball Harper, both of BYU's Department of Botany and Range Science.

The Salt-Desert Shrubs unit is devoted to the study of ecology and management of salt-desert shrub ranges covering vast acreages of the West. The improvement of these ranges is dependent upon careful management of plant resources, because artificial regeneration is very difficult. The salt-desert shrub ranges occupy about 50 million acres, mainly in the Great Basin of Utah and Nevada, but also in other States and other physiographic provinces.

Researchers of the Salt-Desert Shrubs unit are focusing on the ecological classification and productivity potentials of plant communities and species. They are also inventorying and describing wildlife populations and their influences in the ecosystem; and developing management systems for livestock production to maintain or improve plant-soil resources.

Shrubs are used to stabilize and improve the appearance of construction and roadside scars. They are valuable soil stabilizers and can provide quick ground cover and many have deep and fibrous root systems.

To maintain wildland shrubs on livestock and big game ranges, recreation sites, and soil erosion control plots, the impact and ecological relationships of insects to the total ecosystem must be better understood. Insects, such as the tussock moth, can have a very damaging impact on shrubs.

The researchers concerned with watershed protection and rehabilitation are evaluating methods and plant materials for the rehabilitation of oil shale spoils and open pit coal mine spoils.

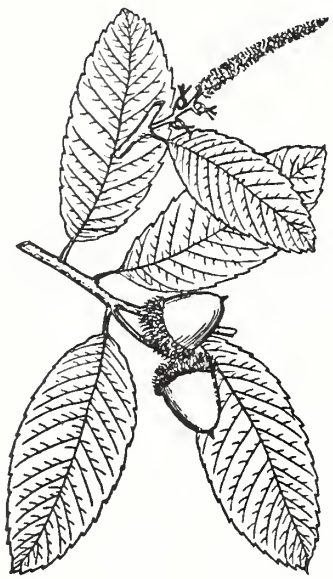
Longstanding cooperative research on improving and rehabilitating game ranges is conducted with Utah Division of Wildlife Resources personnel at the Forest Service's Great Basin Experimental Range near Ephraim, Utah. Experimental gardens where shrubs are grown for intensive study are located at Boise, Idaho; Reno, Nevada; and Provo and Ephraim. Adaptation and selection planting sites are widely distributed in the Intermountain area. Some of these gardens and plots are located on land maintained by other Forest Service units or on land owned by cooperating agencies or private citizens.

The work on shrubs being carried out at the Shrub Lab appears to be the most advanced of its kind in progress anywhere in the world. In addition to its importance to America, especially the West, shrub research could assist arid and semiarid developing countries.

A. Perry Plummer, for many years the leader of the Shrub Improvement and Revegetation unit, says, "It is interesting to note that for decades farmers have considered sagebrush and many other shrubs as a nuisance to be cleared off the land so grass could be planted. We now know that many of these are much more nutritious than grass. The time may soon come when farmers will plow the grass under to plant sagebrush."

-by Delphia Noble,
Intermountain Station

Publications



Tanoak acorns are an important food for bear, deer, squirrels, chipmunks, birds, and other animals; the tree produces the largest acorn crop of any Pacific coast oak. (Drawing from Charles S. Sargent's "Manual of the Trees of North America," courtesy Dover Publications, Inc.)

Tanoak bibliography issued

Tanoak (*Lithocarpus densiflorus*) is one of California's commercially promising hardwood species, according to Research Forester Philip M. McDonald of the Pacific Southwest Station. In the publication, "TANOAK . . . A Bibliography for a Promising Species," McDonald lists 177 reports about the uses of tanoak and its dendrology, synecology, and insect and disease problems.

Several articles document the early use of tanoak bark as an important source of high-quality tannin. Later articles report on tests of tanoak wood, conducted at Federal and State wood products laboratories. These studies show that tanoak machines easily, takes stains and finishes well, does not split when fasteners are used, and forms strong joints when glued. It is ideal for paneling, veneer, plywood, pallets, flooring, baseball bats, boat parts, and crossties. Tanoak chips, when mixed with chips from other species, make satisfactory printing paper.

"Tanoak is a tough, hard, attractive wood," McDonald notes. "There are more than 2 billion board feet of tanoak sawtimber in California and 1-1/2 billion board feet in Oregon. This is an under-utilized resource that could be used to increase wood and fiber production."

Copies of the bibliography (General Technical Report PSW-22-FR15) are available from the PSW Station.

Insect infestations and recreation

How much does a large outbreak of forest insects affect recreational use of an area? Very little, according to researchers who studied an outbreak of the Douglas-fir tussock moth in the Blue Mountains of northeast Oregon.

The study was made in the summer and fall of 1975, a year after DDT was used to control the outbreak. Information was gathered by interviewing people at recreation sites, owners of services catering to recreationists, and from telephone interviews with deer and elk hunters.

The people interviewed were questioned to find out if they had been aware

of the insect problem and whether they had changed their plans to visit any part of the affected area because of the outbreak. When first-time visitors were questioned, without specific mention of the tussock moth, only 2 percent mentioned the moth. When repeat visitors were questioned the same way, 9 percent said they had heard about changes in the Blue Mountains they thought were caused by the tussock moth. When all respondents were asked whether they had changed their plans to visit the Blue Mountains over the previous two or three years, one percent gave the tussock moth as a reason for the change.

People who fished, hiked, or gathered forest products such as berries seemed more aware of the infestation than people traveling through or visiting the area for sports or other activities. Visitors during deer and elk season were more aware of the situation than summer visitors. Affected areas were avoided more by local residents than by people living farther away. Nearly all of the operators of packer-guide services and resorts received inquiries about the tussock moth and DDT spraying. More than half received inquiries about salvage logging. Overall, operators believed game populations and gasoline shortages influenced their businesses more than the tussock moth, DDT spraying, or logging.

The authors concluded that there was little or no significant relationship between the moth damage and the amount and type of recreation use. However, they did point out that there may be important long-term effects associated with insect control programs, such as accelerated road building for salvage logging. They suggest that the long-term impact on recreation should be included in evaluations of alternate ways to manage insect outbreaks or other similar natural events.

Copies of "Impact of the Douglas-fir Tussock Moth on Forest Recreation in the Blue Mountains," USDA Forest Service Research Paper PNW-224, by Kent B. Downing, Phillip B. Delucchi, and William R. Williams are available from the Pacific Northwest Station.

New model developed for computing yield tables

A new research paper has been released by the Rocky Mountain Station that describes a computer program for computation of yield tables for even-aged and two-storied stands of Black Hills and southwestern ponderosa pine, Engelmann spruce-subalpine fir, and even-aged lodgepole pine stands. This paper supersedes Research Papers RM-21, RM-26, RM-43, RM-72, RM-79, RM-87, RM-134, and RM-163.

The program, RMYLD, is a whole-stand model that does not depend on the distance between trees in the stand. Advantages of such models are the ability to utilize conventional inventory data, relative simplicity, and fast computation time. RMYLD has provisions for a wider range of stand conditions and management alternatives than previous models.

The program is written in standard FORTRAN IV and can be run on most computers that provide 50,000 octal memory locations. Yield tables can be produced at a cost of about 5-10 cents each, excluding program compilation costs.

RMYLD has been developed to compute yield tables for the following species, areas, and stand conditions: (1) even-aged and two-storied stands of

ponderosa pine in the Black Hills of South Dakota and Wyoming; (2) even-aged stands of lodgepole pine in Colorado and southern Wyoming, including effects of dwarf mistletoe; (3) even-aged and two-storied stands of ponderosa pine in Colorado, Arizona, and New Mexico, including effects of dwarf mistletoe; (4) even-aged and two-storied stands of Englemann spruce-subalpine fir in the central and southern Rocky Mountains.

For a copy of this report, write the Rocky Mountain Station and request "RMYLD: Computation of Yield Tables for Even-aged and Two-storied Stands," Research paper RM-199-FR15, by Carleton B. Edminster.

Ponderosa pine studied

Foresters who are bringing stands of ponderosa pine under intensive management may be interested in two new reports from the Pacific Southwest Station. In one, researchers describe an improved technique for determining site index of managed stands. In another, they show how they were able to double tree growth in a young plantation by removing brush and applying nitrogen fertilizer. Reports of both these studies are now available from the Pacific Southwest Station.

In "Site Classification of Ponderosa Pine Stands Under Stocking Control in California," researchers Robert F. Powers and William W. Oliver explain how to use their new site classification system for estimating tree growth in moderately stocked stands. The system can be used to predict height growth to 80 years of age, and is recommended for use in the Sierra Nevada, interior Coast Range, and Warner Mountains of California. According to the researchers, the system is an improvement over earlier ones, in that the previous guides do not apply well to stands where stocking is controlled. For example, earlier site indexes generate curves that underestimate later height growth; the new curves, in contrast, indicate that rapid rates of height growth are possible to age 80, providing that stocking densities are moderate and that soils are fairly deep.

Powers and Oliver have also developed a system for determining site index in very young stands—those 4 years old at breast height, or older, with dominants less than 20 feet in height. They say that this system, too, is an improvement over conventional systems, most of which are inaccurate when applied to stands this age. They give a separate equation for predicting tree growth on sites where skeletal soils are formed from schists, as the high amount of rock in this soil restricts root development and thus hinders tree growth. Details on the systems are in Research Paper PSW-128-FR15.

In a second study, Powers and colleague Grant D. Jackson measured the response of young ponderosa pine in plantations to applications of 200 or 400 pounds of nitrogen fertilizer per acre. The plots were located in the foothills of the west-side Sierra Nevada, on two soil types—Cohasset and Mariposa. At the beginning of the experiment, Powers and Jackson estimated that the Cohasset soil was about 40 percent more fertile than the Mariposa soil, which was low in nitrogen. On some plots, the dense understory of brush (whiteleaf manzanita) was cleared.

When the plots were checked one growing season after treatment, results showed that brush removal and fertilization at 200 pounds per acre doubled height

growth in pines on the Mariposa plots. On Mariposa sites where brush was not cleared, height growth of the pines did not improve. The treatments did not affect the height of the trees on the Cohasset plots, but they did increase needle weight of these pines. This increase, along with the improvements measured on the Mariposa plots, will probably continue, acording to the authors. More information about the experiment is in Research Paper PSW-132-FR15, "Ponderosa Pine Response to Brush Removal and Fertilization in a Plantation on Contrasting Soil Types."

Tables help predict slash weights

If you need to calculate the weights of slash that remains after timber cutting or thinning, procedures developed by Intermountain Station researchers can help.

The methods have been published in a General Technical Report titled "Handbook for Predicting Slash Weight of Western Conifers." Authors are James K. Brown, J. A. Kendall Snell, and David L. Bunnell of the Station's Northern Forest Fire Laboratory, Missoula. The procedures have also been computerized for use with the Northern Region's stand examination inventory.

With information in the handbook, land managers can predict weights of slash using tables of either crown weight per tree by d.b.h., or crown weight per square foot of tree basal area by d.b.h. Slash weights include crown (live and dead branchwood and foliage) and unmerchantable bole tips to 3-, 4-, and 6-inch diameter limits.

For your copy, write to the Intermountain Station and ask for GTR-INT-37-FR15,

Introduced fungi improve seedlings

"The establishment and maintenance of good populations of appropriate mycorrhizal fungi must become an integral part of good nursery management," according to Mycologist Jim Trappe of the Pacific Northwest Station. In a recent report Trappe points out that poor growth of seedlings in nurseries, often blamed on other factors, may actually be caused by the lack of suitable mycorrhizal fungi. It is now possible to significantly improve seedling performance both in the nursry and at planting sites by inoculating nursery soils with selected fungi.

Trappe reviews the functioning of mycorrhizae—the little-understood fungus-root structure—and its importance to about 95 percent of the world's vascular plants. Mycorrhizal fungi not only help plants absorb nutrients, but they also protect them from disease and promote plant growth. Fungal species vary considerably in their ability to perform these functions with specific plant species. They also vary widely in their tolerance to extremes of temperature, moisture, and soil toxicity, and in their interactions with other soil organisms. This diversity makes it possible to select fungi with desired traits for inoculation in nurseries. That selection might also be made partly on the basis of whether the mushrooms are edible. Seriously poisonous mushrooms should be avoided.

In the report, Trappe discusses kinds of inoculum, inoculation methods, ways to isolate and grow fungi, and some of the practical considerations of operational use of fungi in nurseries. He also includes an historical overview and background on mycorrhizal inoculation and a peek into the future: "Eventually we may have mycorrhiza-improvement programs that are just as comprehensive and well financed as the large-scale tree improvement programs that have been developed in various countries around the world," he says.

Copies of "Selection of Fungi for Ectomycorrhizal Inoculation in Nurseries" by James M. Trappe, which appeared in The Annual Review of Phytopathology for 1977, are available from the Pacific Northwest Station.

Harvesting levels and employment

Timber management decisions can have a substantial impact on a community when the wood products industry provides a significant portion of the community's employment.

The Intermountain Station has issued a report that discusses and presents methods for estimating changes in employment in wood products industries, and total community employment, as the level of timber harvesting rises or falls.

Author Enoch Bell, principal economist at the Forestry Sciences Laboratory, Missoula, says the procedures can be used by land management planners to portray the employment. effects of alternative harvest levels.

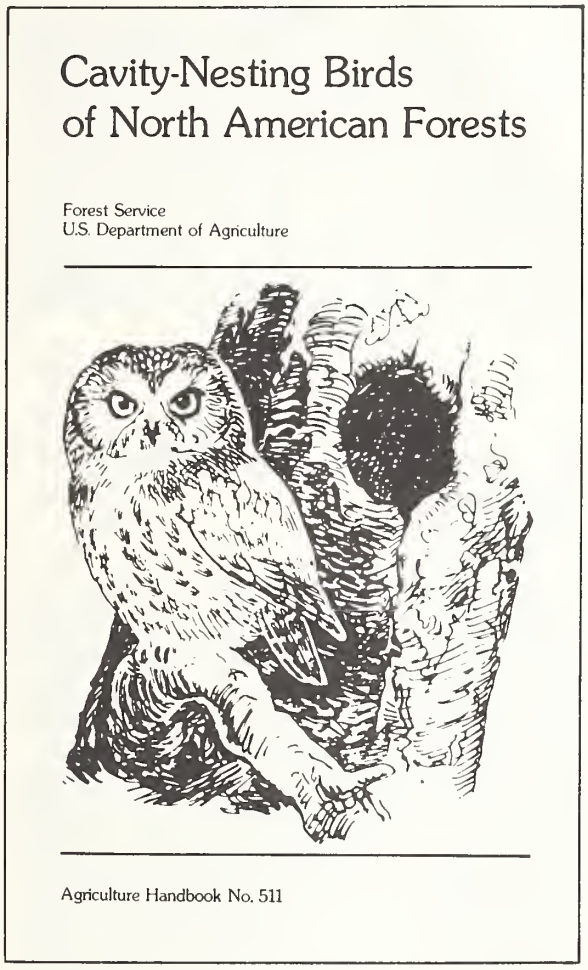
Copies of "Estimating Effect of Timber Harvesting Levels in Employment in Western United States," INT-RN-237-FR15, are available from the Intermountain Station.

Thinning to increase timber yield

Thinning increases timber yield by utilizing trees that would otherwise die and by increasing growth of the remaining trees. Since no timber stands in the Pacific Northwest have been thinned regularly for 60 to 80 years, there is no record of gains over long periods. However, researchers have used information on the structure and development of both natural and thinned stands to forecast the long-term increase in usable wood from various regimes of thinning.

A new publication from the Pacific Northwest Station explains the concepts on which such forecasts are based and summarizes the results that may be expected from thinning. These gains vary according to the quality of site and the units of measurement used. Guidelines for thinning are also provided.

Copies of "Effects of Thinning on Yield of Douglas-fir: Concepts and Some Estimates Obtained by Simulation," USDA Forest Service General Technical Report PNW-58, by Donald L. Reukema and David Bruce, are available from the Pacific Northwest Station. A companion publication, "Douglas-fir Managed Yield Simulator—DFIT User's Guide," by Bruce, Reukema and Donald J. DeMars was reviewed in the January, 1978 issue of Forestry Research What's New in the West. Copies of this publication (General Technical Report PNW-57) are also available.



New life from dead trees

Most cavity-nesting birds — woodpeckers, chickadees, swallows, wrens and others — are insect eaters that rely on holes or cavities in trees to establish nests and rear their young. Many prefer dead trees or snags. These cavity-nesting birds play an important role in controlling endemic insect populations, thus helping to prevent or delay epidemics of tree-killing insects in the forest.

Managers of forest resources are developing a new respect for cavity-nesting birds, and are planning management programs to provide them with essential habitat. In fact, Forest Service regulation now requires that each National Forest not only preserve snags to support present bird populations, but to plan ahead by saving some large, living trees that will become snags for future bird generations.

A new pocket-sized book, "Cavity Nesting Birds of North American Forests," summarizes what is currently known about the habitat requirements of 85 cavity-nesting bird species. The handbook, illustrated with color drawings, is co-authored by Wildlife Biologists Virgil E. Scott and Charles P. Stone, U.S. Fish and Wildlife Service, and Keith E. Evans and David R. Patton, U.S. Forest Service.

It was published by the Forest Service as an aid to owners and managers of forest lands, but should be equally useful to teachers, park naturalists, land use planners, and others with a special interest in birds.

If you would like a copy, send $2.75 to the Superintendent of Documents, Government Printing Office, Washington, D.C. Request "Cavity Nesting Birds of North American Forests," Agriculture Handbook 511, GPO Stock No. 001-000-03726-4.

A prediction tool

Tables for estimating cubic volumes of wood, wood residue, and bark for four species—ponderosa pine, lodgepole pine, western larch, and Douglas-fir are available in an Intermountain Station report. The tables, developed to use measurements obtained in the field, have been

prepared primarily to predict stem residue volume that may result from thinning or harvesting.

The tables and pertinent information are included in "Estimating Merchantable Volume and Stem Residue in Four Timber Species," INT-RP-196-FR15, by James L. Faurot. Mr. Faurot is a professor at the School of Forestry, University of Montana, Missoula.

The report is based on a study conducted by the Montana Forest and Conservation Experiment Station, University of Montana, and the Intermountain Station.

RUN WILD

A new computer storage and retrieval system for wildlife habitat information, titled RUN WILD, has been developed, and provides a management file on 721 vertebrate species in Arizona and New Mexico.

It contains information on: species distribution, protection status, key habitat factors, food and cover requirements, and references for each species.

Research Wildlife Biologist David Patton, Forestry Sciences Laboratory, Tempe, Arizona, and Dale Jones, Director of Wildlife Management at the U.S. Forest Service's National Headquarters in Washington, D.C., spearheaded the two-year effort to develop this program.

Currently the RUN WILD system has seven files containing three levels of information. The first level provides a general listing of wildlife in Arizona and New Mexico. The second level is more specific and contains files of species habitat associations. The third level provides management information and references for individual species. The main program was written in FORTRAN IV, which is accepted by most computers. Access to the computer is by telephone.

If you would like details on RUN WILD and how to use it, write the Rocky Mountain Station and request General Technical Report RM-51-FR15, titled "RUN WILD - A Storage and Retrieval System for Wildlife Habitat Information," by David R. Patton.

Fir regeneration studied

Two reports on regeneration of true fir in northern California are now available from the Pacific Southwest Station. One report describes a study in which herbs and brush species were sampled on cutover sites. The purpose of the research was to learn more about the plant communities that develop after cutting and site preparation. This information can, in turn, be used to determine which species interfere with, or benefit, survival and growth of fir seedlings. At the present, low-growing plants which might affect fir regeneration are generally removed "more or less indiscriminately," according to the report. The researchers conducting this study sampled 100 points on 32 cutover sites and 50 points on 9 adjacent uncut areas. They found a total of 58 different plant species on the logged sites, the most abundant of which were pinemat manzanita, lupines, the waterleaf *Phacelia mutabilis*, needlegrasses, the evening primrose *Gayophytum nuttallii*, Sierra gooseberry, firs, sedges, and red flowering currant.

One of the basic aims of the study was to determine whether species composition on uncut areas would indicate relative abundance of species that would

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appear on the cut areas. Species composition varied, however, between cut and uncut sights; composition on uncut sights, therefore, was not considered a reliable indicator of early succession on logged-over sights.

The research was conducted by Donald T. Gordon, a California authority on true fir, who recently retired from the Pacific Southwest Station, and by Eugene E. Bowen, who was Gordon's assistant in the study. Copies of the publication, "Herbs and Brush on California Red Fir Regeneration Sites: A Species and Frequency Sampling," (Research Note PSW-329-FR15) are available from the PSW Station.

In the second report, Gordon gives the results of a 16-year study of cone production on red and white fir in northeastern California. For this research, cones were counted annually on selected firs at the Swain Mountain Experimental Forest. At the outset of the experiment, only mature, dominant trees were used; later, younger firs, about 75 to 100 years old, were added to the study. Trees were tagged, measured, and described to indicate location in stand, slope and aspect of site, diameter, height, age class, crown class, vigor, and density.

In a related study of seedling regeneration at the Experimental Forest, an adequate number of fir seedlings became established only after an average of 45 cones per study tree were formed. In the cone study, production at or above this "threshold level" occurred most often at 1- or 2-year intervals. Whenever this average annual number of cones per tree fell below this level, the productivity from tree to tree was erratic, compared to other years, and half or more of the trees produced less than a dozen cones each.

Data gathered from the 5-year-period in which production from young-growth was analyzed may indicate promising trends, according to Gordon. If the observed cone production of these immature firs continues to compare favorably with that of old-growth, natural regeneration may be a viable silvicultural option in intensively managed young-growth fir stands.

Details are in Research Note PSW-330-FR15, "White and Red Fir Cone Production in Northeastern California: Report of a 16-Year Study," by Donald T. Gordon. Write to the PSW Station for copies.

You won't want to miss the October issue. Feature topics include: Chaparral Management Research; A New, Improved Running Skyline Yarder; Fire in Multiple Use Management; Growing Containerized Seedlings in Greenhouses; and much more.

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